Overview of Controls: Why They Work and How They Function

Toxicants

Kathy Fagerstone
USDA/APHIS/WS/NWRC
1716 Heath Parkway
Fort Collins, Colorado 80524-2719

A Review of Toxicants

Introduction

Of the many vertebrate Toxicants registered for field use in the United States in the past, only a few are currently registered. Relatively few studies have been conducted to evaluate efficacy or hazards to nontarget wildlife. the recent emphasis on reregistration by the EPA has increased data requirements for pesticides, prompting new toxicity, efficacy, and nontarget hazard studies. This paper provides a brief summary of registered vertebrate toxicants.

FUMIGANTS

Aluminum Phosphide (PhostoxinR, PhosTekR, etc.)

Use: Fumigant for burrowing animals such as pocket gophers, native mice (voles, deer mice), prairie dogs, ground squirrels, marmots, woodchucks, chipmunks, and moles. Restricted use pesticide.

History: aluminum phosphide was introduced as a fumigant for stored products in the 1930s by DEGESCH, a German company. It was registered for mammal control in 1981.

Characteristics/Mode of Action: Dark grey or yellowish crystals formulated into 3-g tablets or 600-mg pellets containing about 56% active ingredient. The aluminum phosphide reacts with moisture in burrows to release phosphine (PH3) gas. The gas is absorbed through the respiratory passages and enters the bloodstream to block fermentation processes in cells and alter hemoglobin.

Toxicity: Potent mammal toxicant. At a concentration of 1000 ppm PH3 is lethal to humans after a few breaths. However, hazardous exposure levels have not been observed in the field under these uses, partially because the human nose can detect quantities of the gas as low as 1.4 ppm. Inhalation LCL0 values vary from 70 mg/m3/2H for cat to 380 mg/m3/2H for mouse.

1997. Pages 17-24 in Wildlife Damage Management for Natural Resources Managers. Western Forestry and Conservation Association, Portland, OR. (A workshop held Oct 1-2 in Olympia, WA. Compiled by Dale L. Nolte & Kimberly K. Wagner).

Efficacy: Effective for some uses. burrow fumigants are generally not effective for pocket gophers. It has not been effective for use against Belding's ground squirrels in northern California, perhaps because of low ambient temperatures or the lack of adequate soil moisture.

Nontarget Hazards: Burrow fumigants will kill all animals residing in treated burrows so it is important to verify that burrows are occupied by target animals. Animals potentially affected by primary poisoning include nontarget rodents, burrowing owls, reptiles and amphibians, rabbits, raccoons, fox, weasel, and skunk. No secondary poisoning hazards exist with burrow fumigants.

Acrolein (Magnacide)

Use: Restricted use. It has recently received registration in California as a 24c for controlling burrowing rodents (California ground squirrels and pocket gophers, and in Utah, Wyoming, and Nevada.

History: Shell Oil company formulated the compound in 1948 and patented it in 959 as an herbicide. Baker Performance Chemicals received a 24c registration in California in 1993 as a burrow fumigant.

Characteristics/Mode of Action: Acrolein is a colorless volatile liquid with a pungent odor. It is sold in pressurized cylinders and is sprayed into the burrow opening, where it quickly volatilizes. The burrow entrances are quickly sealed off with soil immediately following application.

Toxicity: Acrolein is a general cell toxicant that kills through its sulfhydryl reactivity. Exposure to skin can cause burns and inhalation irritates the respiratory system, throat and eyes at concentrations far below lethal concentration. LD50 values range from 7 mg/kg to 46 mg/kg for mice, rats, and rabbits.

Efficacy: Field efficacy has been >90% for California ground squirrels but only 59% for northern pocket gophers.

Nontarget Hazards: See aluminum phosphide.

Gas Cartridge (APHIS Gas Cartridge, Giant Destroyer, Smoke'Em, Gopher Gasser, Dexol Gasser, and others)

Use: Used as a burrow fumigant for pocket gophers, prairie dogs, ground squirrels, marmots, and moles.

History: Gas cartridges were developed by the former Bureau of Biological Survey more than 30 years ago. Gas cartridges are available through the Pocatello Supply Depot and can be Purchased from WS state directors or hardware stores. There are also a number of commercial products on the market.

Characteristics/Mode of Action: The APHIS cartridge contains 2 active ingredients, sodium

nitrate and charcoal. The main combustion product is carbon monoxide.

Toxicity: 200 ppm of carbon monoxide in inhaled air produces symptoms of poisoning in a few hours. 1000 ppm can cause unconsciousness in 1 hour and death in 4 hours.

Efficacy: The cartridges are effective for prairie dogs and ground squirrels. Efficacy for Richardson's ground squirrels averaged 84%. They are not effective for control of northern pocket gophers (17.1%).

Nontarget Hazards: See aluminum phosphide.

ANTICOAGULANTS

Chlorophacinone (Rozol) and Diphacinone (Ramik)

Use: Pocket gophers, moles, deer ice, voles, ground squirrels, muskrats, and rats. Diphacinone is also registered in Hawaii for mongoose control.

History: Diphacinone was first patented in 1954. It was used in humans as a blood-thinning agent for preventing blood-clots for many years. It was introduced as a rodenticide in 1957. Chlorophacinone was developed by LIPHA and was introduced into the US more than 10 years after diphacinone.

Characteristics/Mode of Action: Chlorophacinone and diphacinone act by interfering with the vitamin K cycle, reducing blood clotting ability. Anticoagulants must be fed over several days. They accumulate in the liver and gradually dissipate over time.

Toxicity: When prescribed for humans, the daily dose of diphacinone (equal to 1.3 pounds of bait) far exceeded the potential human exposure to rodenticide baits. An injection of vitamin K returned patients' blood clotting times to normal within 24-48 hours. The toxicity of these anticoagulants (LD50) varies from 0.5-17.0 for rodents, 5.0-15.0 for cats and dogs, and 430-3,158 for bird species.

Efficacy: Fairly effective on California ground squirrels. Spot baiting was effective for Belding's ground squirrels but bait stations showed very low mortality.

ACUTE TOXICANTS

Strychnine Alkaloid

Use: Pocket gophers, moles, ground squirrels (underground baiting with cabbage only).

History: Strychnine has been used for rodent and predator control since the mid-1800s. By the

early 1900s it was used extensively for pocket gopher and ground squirrel control. In 1986, EPA suspended all aboveground registrations of strychnine, allowing underground uses for pocket gophers and moles.

Characteristics/Mode of Action: Strychnine enters the blood rapidly and acts on the central nervous system, blocking neural transmission. Death is due to asphyxia as a result of respiratory paralysis. In nonlethal doses it is detoxified in the liver and metabolized rapidly.

Toxicity: LD50 values (mg/kg) range from 0.5-2.0 for carnivores, 1.5-28.0 for rodents, range from 0.5-2.0 and 2.3-112 for birds.

Efficacy: Strychnine can be 95-100% effective for pocket gophers in the field at the 0.5% concentration.

Nontarget Hazards: **Primary**: Some nontarget small mammals such as golden mantled ground squirrels, deer mice and chipmunks may be killed consuming strychnine baits but no long-term effects on populations have been seen. Gallinaceous birds are generally not vulnerable to strychnine poisoning. Seed-eating birds are very susceptible to poisoning. **secondary**: Strychnine has no cumulative effects and sublethal doses are completely eliminate from the body. Undigested strychnine in the GI tract of poisoned animals can produce toxicity to predators and scavengers, but the GI tract is seldom consumed. Secondary strychnine poisoning to raptors, which eviscerate and remove the GI tract, is not likely based on several field and laboratory studies. Hazards have not been shown to bears, owls, or hawks.

Zinc Phosphide

Use: Pocket gophers, voles and deer mice, muskrats and nutria, prairie dogs, kangaroo rats, cotton rats, ground squirrels. Can be used in some food crops.

History: Zinc phosphide was first synthesized in 1740 and first used as a rodenticide in 1911 in Italy. It was introduced into the US during World War II. It is widely used in the US for field rodents.

Characteristics/Mode of Action: Zinc phosphide is an inorganic, acute rodenticide. Toxicity occurs when it reacts with water and hydrochloric acid in the GI tract of an animal to form toxic phosphine gas.

Toxicity: Zinc phosphide is highly toxic to both mammals and birds. At least 61 acute oral toxicity studies, representing 28 species of mammals and 16 species of birds, have been conducted on zinc phosphide. It is 2-15 times more toxic to rodents than to carnivores. LD50 values range for 5.6-9.3 mg/kg for mammals, and 7.5-67.4 mg/kg for birds. Lethal dietary concentrations (LC50s) range from 468 ppm for bobwhite quail to 2,885 ppm for mallards.

Efficacy: Field efficacy ranges from 85-98% for ground squirrels, 76-100% for prairie dogs, 85-88% for rats in sugarcane, and is over 94% for voles in alfalfa.

Nontarget Hazards: **Primary**: Waterfowl and gallinaceous birds are the most sensitive bird species. Field studies looking at effects of zinc phosphide on nontarget wildlife have generally found non significant effects but since phosphide applications have occasionally killed nontarget wildlife such as rabbits, seed-eating birds, gallinaceous birds, and waterfowl. **Secondary**: Zinc phosphide is not taken up into tissue so it does not pose a secondary hazard to nontarget predators or scavengers.

Cholecalciferol (Quintox and Rampage)

Use: Rock squirrels in New Mexico.

History: Bell Laboratories tested cholecalciferol on commensal rodents around 1975 and begun marketing it in 1984 as Quintox. Registration was granted to Motomco Ltd. in 1985.

Characteristics/Mode of Action: Cholecalciferol (Vitamin D3) is toxic when consumed in large doses. It causes mobilization of calcium from bones to blood plasma and produces hypercalcaemia and calcification of the blood vessels. Time to death is 3 to 4 days.

Toxicity: LD50 values range from 42-44 mg/kg for rats and mice to 80 mg/kg for dogs.

Efficacy: In laboratory tests, it has been effective against ground squirrels and pocket gophers but not against prairie dogs. Field efficacy was only 50% for pocket gophers. Little field data are available for other species.

Nontarget Hazards: There is little potential for secondary hazards to nontarget species.

AVICIDES

Avitrol

Use: Pigeons, house sparrows, blackbirds, and cowbirds in and around structures. Starlings, blackbirds, grackles, cowbirds, and crows in agricultural situations. For use by certified pest control operators only.

History: The chemical 4-aminopyridine was first reported by Koenigs and Gredner in 1931, but its effectiveness in birds was not recognized until 1964 by Goodhue. Avitrol is registered by Avitrol Corp.

Characteristics/Mode of Action: 4-aminopyridine is usually formulated on a grain bait. It affects the nervous system and birds ingesting the material emit distress calls and exhibit erratic flight before death. Treated baits are diluted with untreated bait so only a few birds in a flock ingest a treated particle. The distress displays of affected birds serve to frighten the rest of the flock, causing them to disperse.

Toxicity: LD50 values (mg/kg) are 4.0 for dogs and 20 for white rats. LD50 values for birds range from 1.7 to 8.5 mg/kg. Birds and mammals appear equally sensitive to Avitrol intoxication.

Efficacy: Efficacy is variable. The few birds that consume baited particles treated with Avitrol emit distress cries before dying that usually frighten the rest of the flock and cause them to leave the site.

Nontarget Hazards: Avitrol has low mammalian toxicity and secondary toxicity to raptors, so hazards to these species are unlikely. In field use, individual scavengers such as magpies and crows have been occasionally affected. Some mortality could be expected to other seed-eating birds.

Starlicide

Use: Starlings, blackbirds, crows, magpies, ravens, gulls, and pigeons. Certified pest control operators.

History: In the early 1960s, DRC-1339 was found by the Denver Wildlife Research Center to be an excellent toxicant for starlings na blackbirds. Starlicide was registered by Purina Mills as a pellet for starling and blackbird control. DRC-1339 is registered by USDA/APHIS as a concentrate for mixing baits to control other birds in field situations and it is restricted to use by USDA/APHIS personnel.

Characteristics/Mode of Action: Starlicide is a slow acting, apparently painless, toxicant. In sensitive bird species, death results from uremia (a build up or uric acid in the blood) and circulatory impairment in the liver and kidney.

Toxicity: LD50 values (mg/kg) in birds range form 1.0-4.11 in blackbirds, starlings,a nd grackles; 1.33-517.7 in ravens, crows and magpies; 3.2-17.8 in pigeons and doves; 2.2-10 in gallinaceous birds, 17.8-32 in waterfowl; >100->320 in sparrows and finches; and 100-562 in raptors. Mammals are not very sensitive, with LD50 values of 644-2,000 for rats and mice; >100 for dogs; and about 400 for sheep.

Efficacy: Efficacy is variable but generally good.

Nontarget Hazards: Some primary toxicity can be expected if sensitive nontarget bird species such as robins are feeding with blackbirds and starlings. Mammals and many bird species are relatively insensitive to Starlicide. Starlicide is metabolized or excreted completely within hours so there is no secondary toxicity.

Fenthion

Use: Used on Rid_A-Bird perches as a contact toxicant for starlings, house sparrows and pigeons.

History: Produced in 1957 as an insecticide by Farbenfabriken Bayer. Registered by Rid-A-Bird as a bird toxicant.

Characteristics/Mode of Action: Fenthion is an organophosphate compound whose toxic action is caused by inhibition of acetylcholinesterase. Fenthion is readily absorbed through the skin. Death can occur within minutes but normally takes 2-12 hours.

Toxicity: LD50 values for mammals are relatively high, from 88 to 615 mg/kg. Ld50 values for birds are generally similar and low, ranging from 1.0 for the American kestrel to 4.0-28.0 for gallinaceous birds.

Efficacy: Can be effective for pigeons, starlings and sparrows where they are creating a nuisance situation by roosting in buildings.

Nontarget Hazards: Will affect any bird that lands on the perch. Secondary hazards have been documented with raptors, owls, and avian scavengers from exterior uses and use in open buildings. Secondary hazards to mammals are less because of the low mammalian toxicity.

Conclusions

Currently registered vertebrate toxicants are generally very safe. Risks to nontarget wildlife are usually small, especially when compared to other pesticides. Several factors limit risks:

Registration Safeguards: The EPA registration process lends a large degree of safety to pesticide products by requiring extensive toxicity and nontarget hazards data. In addition, for vertebrate pesticides, EPA frequently requires efficacy data not generally required for other types of pesticides.

Low Volume of Use: The second characteristic that provides a margin of safety for vertebrate pesticides is the low volume of use compared to insecticides, fungicides and herbicides. EPA recently reported that total use of pesticides in the U.S. was approximately 1.2 billion pounds per year. Use in 1991 of fungicides was 147 million pounds, of herbicides was 495 million pounds, and of insecticides was 175 million pounds. In contrast, vertebrate pesticide use is very small. For example, annually about 119,000 pounds of zinc phosphide active ingredient and 10,000 pounds of strychnine are used for control of field rodents such as ground squirrels and pocket gophers. Volumes used for all chemicals were very small. Maximum annual rodenticide used by Wildlife Services was less than 600 pounds, and rodent fumigant use was less than 1000 pounds.

Use Sites Limited in Area: Another factor limiting risk from vertebrate pesticides is the use pattern of the vertebrate pesticides. Most are used in very limited areas, such as the gas cartridge (placed in burrows), and strychnine (used in underground tunnels for pocket gopher control).

Selectivity: Vertebrate pesticides and bait carriers also tend to be fairly selective. Rather than managing vertebrate pests on a species level, the trend in current wildlife damage management is to deal selectively with problem animals or problem situations on a local basis. Future use of toxicants is expected to decline still further as alternate methods of reducing damage to crops and rangelands are developed. Much of the current emphasis at the National Wildlife Research Center is centered on development of repellents and wildlife contraception techniques